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PART I

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RESEARCH ON HEATER-TENSION PADS AND HIGH TEMPERATURE HEATERS

PART I — EVALUATION OF HEATER-TENSION PADS AT 500°F

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(Prepared under Contract No. AF 33(616)-6810
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FOREWORD

This report covers Part I of the work performed on Contract No. AF 33(616)-6810 under project No. 1347. The project was administered under the direction of the Deputy for Test and Support, Aeronautical Systems Division. This part of the project was monitored by the Structures Division of North American Aviation, Incorporated, of Los Angeles, California as part of the structural test program of the B-70 aircraft. Mr. J. C. Sanchez of North American Aviation served as the monitoring agent.

Part II of this report describes the research work performed in the development of a micro-film heater for operation at high temperatures.

Mr. Norbert Martin contributed to the preparation of this report.

ABSTRACT

Two hundred and fourteen 120 volt 5 kilowatt per sq. ft. micro-film heaters for operation to 600°F were built for heater reliability studies and for use in Heater-Tension pad tests. This micro-film heater has proved to be robust and sufficiently reliable for applications to large scale testing.

The procedures for constructing "500°F 20 psi." heater-tension pads employing a silicone rubber and phenolic-epoxy adhesives have been established. Endurance tests indicate a high degree of reliability.

Success in building heater-tension pads utilizing a fluorinated elastomer "Viton" for operation at 600°F and 20 psi. has been delayed by difficulties in bonding to the Viton. However, the availability of thicker and sponged Viton suggests that this problem can now be solved.

Tests made on the temperature distribution of honey-comb structures indicate that the desired degree of uniformity can be attained.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

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1. INTRODUCTION

It was the general objective of this part of the investigation to determine the reliability of the micro-film conduction heaters developed at the University of Colorado and to evaluate tension pad materials and adhesives for operation in Heater-Tension Pads under a tensile load of 20 psi., and at temperatures of 500 to 600°F. The work was carried out under the direct guidance and supervision of the Structures Division, North American Aviation, Inc. as the monitoring agent for the government. To meet the requirements of the B-70 structural test program, the following specifications and objectives were designated by NAA: The heater was to be designed for 120 volt operation with a power rating of $5kw/Ft^2$ and with not more than a 40% reduction in power at 500°F and 120 volts; the heaters to remain operational for a minimum of 100 hours at 600°F; temperature distribution over the heater and over the test structures to be as uniform as possible; the heater to be reasonably robust and as reliable as possible; the heater size to be 5¼ x 5¼ inches and the evaluation of tests of Heater-Tension Pads to be conducted with the pads bonded to stainless steel structure specimens.

The reduction in size of the heaters from 6¼ x 6¼ inches to 5¼ x 5¼ inches and the reduction in the rating of the heaters from 30 kw/sq ft at 440 volts to 5kw/sq ft at 120 volts required considerable effort in heater redesign and in rebuilding masks. The fixtures in the vacuum system were redesigned and rebuilt so that two heaters and two sets of tabs could be evac-plated per run. This quadrupled the rate of the vacuum processing of heaters. A change in anodizing conditions to improve heater reliability required considerably more effort in improving the procedures in bonding the terminals to the heaters. This work was

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performed during the period 1 July to 15 September preceding the beginning of this contract and the work will therefore not be reported in this report. The foregoing work was planned in close collaboration with NAA by conference with J. C. Sanchez during a week's visit the first part of August.

During the period of this investigation 15 September to 15 December 1960, 64 heaters were furnished NAA for their testing program. In addition, 8 completed heater-tension pads and a honey-comb panel mounting 9 heaters for testing uniformity of temperature distribution on structure were furnished. During this same period 150 heaters were used in the testing program at the University of Colorado and 109 tension pads were built and utilized in numerous experiments in the evaluation of pad materials and adhesives.

2. MICRO-FILM CONDUCTION HEATERS

2.1 QUALIFYING TESTS AND RELIABILITY

During the second month a test for qualifying all heaters before these were incorporated into a tension pad was initiated. The test consists of placing the heater foil between two pads of silicone rubber under sufficient pressure (1 psi.) to insure good thermal contact. The rubber serves to make continuous surface contact with the heater and foil and also as a heat sink during the test, since the thermal conductivity of silicone rubber is surprisingly high. The heater is then excited at the rated voltage of 120 volts and therefore rated power until the heater reaches 500°F, at which time the power is reduced sufficiently to hold the temperature at 500°F for one minute. As an indication of heater reliability only one in a series of seventy heaters failed to meet this test, and indications are that this failure was caused by local buckling and cracking due to insufficient contact pressure. Most of these heaters were incorporated into tension pads and of these 90% were still operational after tension pad failure. Since

all tension pads were tested to failure and since the pads were being used to study pad materials, adhesives and bonding procedures, the above figures show that these heaters are quite reliable even under adverse conditions.

2.2 ENDURANCE TESTS

One heater #R-148 was operated 194 hours at 550°F without failure and another #R-158 360 hours at 550°F without failure. Another heater #R-292 bonded to an aluminum plate was used for two months as an auxiliary heater for curing adhesives at 500° and tension pad testing at 500° and 600°F. No accurate record of operating periods was made. However, it is estimated that it has operated at 500 and 600°F for well over 1000 hours and is still operational.

3. HEATER TENSION PAD TESTS

3.1 INTRODUCTION

The heater-tension pads used in this evaluation program cover a relatively flat area (5¼ x 5¼ in.) of the structure to be heated. The heater-tension pad consists of a 20 mil sheet of soft aluminum foil with a micro-film heater formed on one face. Covering the heater face of the aluminum foil and bonded to it is a pad of high temperature elastomer. To the other surface of this pad is bonded a flat ¼ inch steel plate of the same size as the pad. This plate called the "load plate" is for the purpose of applying a concentrated tensile load at its center which in turn is distributed over the pad by the rigidity of the loading plate.

One hundred and nine heater tension pads were built and used in establishing bonding techniques, evaluating adhesives and performing endurance tests. Most of these were each used in several experiments and many experiments were made on components not involving completed tension pads. Twenty-two of the above pads were used in studying the silastic 80 pad and the remainder in studying a fluorinated elastomer, "Viton".

3.2 EVALUATION OF SILASTIC 80 PADS

Twenty-two pads of new and reused silastic 80, many of which were rebonded several times, were built and used to test various adhesives and bonding techniques at the several interfaces at 450°F and 510°F and at 20 psi. tension load. By means of many experiments performed on the heater-tension pads and a large amount of previous work performed, the bonding procedures for constructing a silastic 80 heater-tension pad and bonding it to structure were established for those adhesives which showed promise. These procedures are detailed in

Appendix A. The steps in bonding the load plate are given in A-1; the steps in bonding the heater in the tension pad are given in A-2 and the steps in bonding a completed heater tension pad to structure are given in A-3. Representative tests, results and conclusions utilizing the foregoing bonding procedures are given in table 1. Subsequent to establishing the above bonding procedures, six heater tension pads of silastic 80 using adhesive 6-127 in the load plate interface, 201-A in the heater interface and F.P.L.-878+Al pigment in the structure interface were tested at 510°F and 20 psi. Five of these heater-tension pads operated for 100 hours without failure. Reliability studies of this type of H-T pad were discontinued in order to investigate a new type of fluorinated elastomer pad and a new type of silicone-epoxy phenolic adhesive with the hope of raising the maximum operating temperature to 600°F.

3.3 EVALUATION OF VITON PADS

Eighty-seven pads of new and used Viton, many of which were rebonded several times, were built and used to test old as well as new adhesives and also to establish the bonding techniques at the several interfaces at 550°F and 20 psi. tension load. The bonding procedures established for the adhesives (see table 3 for list of adhesives tested) which showed promise, are detailed in Appendix B. The steps in bonding the load plate to Viton using adhesives #60 or ESP-4 are given in B-1; the steps in bonding the heater to the tension pad are given in B-2, and the steps in bonding the completed heater-tension pad to structure are given in B-3. Representative tests, results and conclusions utilizing the above procedures are given in table 2. Of the adhesives tested with the Viton pad, only the F.P.L. 878-phenolic-epoxy formulation pigmented with Al or Al_2O_3 and the ESP-4 adhesives were found to be promising. However, it was found to be very difficult to obtain good contact over all the interface area on account of the small compressibility of

TABLE 1

HTP* EVALUATION TESTS WITH PADS OF SILASTIC 80

HTP* No.	Adhesive at H**	Bonding Procedure & Special Treatment	Objective	Time Hours	Temp. of	Load PSI	Results & Conclusions
C-83	6-127	Primed with 796.	Test reliability of 450°F pads technique.	153	450	20	Technique reliable.
C-123	6-127	Primed with 796.	"	100	450	20	" "
R-119	6-127	Primed with 796, pad scored, cleaned with Toluene Bonded with atmospheric pressure at 350°F for 30 min. post cured 5 hr. at 450°F.	Test ability of 450°F pad to withstand 500°F.	88	500 to 550	20	Did not withstand 100 hr. at 500°F.
R-132	196-A	Squared, primed with 796, bonded with atmospheric pressure at 450°F for 3 hrs. Baked at 450°F for 16 hrs.	Test new tough-high temperature adhesive.	0	70	25	Bond failed due to incomplete cure of new adhesive.
R-133	196-A	Squared, primed with 796, bonded with atmospheric pressure at 450°F for 239 hrs.	Find a curing technique to enable the testing of the new adhesive.	164	500	20	Adhesive was cured and found to adhere at 500°F+ for over 100 hrs.
R-130	201-A	Squared, primed with 796, bonded with atmospheric pressure at 450°F post cured 18½ hrs.	Test new high temp. adhesive.	176	500 to 550	20	Adhesive found to adhere above 500°F for over 100 hrs.
R-148	201-A	Pad scored & primed with 796. Bonded at 350°F for 30 min. at atm. press.	Test adhesive 201-A at 540°F and 20 psi.	10	540	20	Adhesive 201-A should not be used above 510°F.

* Abreviation for Heater-Tension Pad

** H refers to the Heater-Pad interface

TABLE 1 (Continued)

HTP* No.	Adhesive at H**	Bonding Procedure & Special Treatment	Objective	Time Hours	Temp. of	Load PSI	Results & Conclusions
R-138	6-127	Pad scored & primed with 796. Bonded at 350°F for 30 min. at atm. press.	To Test 450°F pad for endurance.	528	450	20	Pad did not fail 450°F pad is reliable for 500 hours.
R-176	196-A	Pad scored, milled flat, and primed with 796. Bonded with atmospheric pressure at 425°F for 1 hr. Post cured 64 hrs. at 450°F.	Test effect of milling and profuse scoring.	64	450	0	Bond failure due to over scoring caused heater failure.
R-202	6-127	Pad scored, milled flat, and primed with 796. Bonded with atmospheric pressure at 400°F for 30 min. Baked at 500°F over night.	Test usability of 6-127 at 500°F.	1/2	550	20	Bond failure due to brittleness of adhesive 6-127 unusable above 500°F.
R-165	201-A	Pad scored, milled flat, and primed with 796. Bonded with atmospheric pressure at 350°F for 30 min. Baked 64 hrs. in 450°F oven.	Test mechanical scoring of pad.	110	500	20	Bond failure due to aging of adhesive. Evidence indicates shelf life of adhesive had been exceeded, scoring successful.
R-158	201-A	Pad scored and primed with 796. Bonded at 350°F for 30 min. at atmospheric pressure.	Test adhesive 201-A at 550°F.	360	550	0	Due to failure of load plate, bond load was not applied until after 360 hrs. Adhesive still good.
R-192	6-127	Pad scored, milled flat and primed, bonded at 400°F for 30 min. at atmospheric pressure Baked in 500°F oven overnight.	Test new terminal technique.	1	450	20	Bond failure due to overbake at 500°F. Terminal technique sucessful.

TABLE 2

HTP* EVALUATION TESTS WITH PADS OF VITON

HTP*	Adhesive L**	Adhesive H+	S++	Pad Thickness	Time Hours	Load PSI	Temp. of	Object	Results and Conclusions
R-135	35-0	35-0	60	1/8"	70	20	550	Test viton asbestos	Bond failure in viton asbestos. Asbestos unsuitable.
R-149	35-0	35-0	60	1/8"	1/2	20	500	Test viton asbestos	Bond failure in viton asbestos. Poor contact due to thin viton.
R-154	35-0	35-0	60	1/8"	1/2	20	515	Test viton asbestos	Bond failure in viton asbestos. Poor contact due to thin viton.
R-156	35-0	35-0	60	1/8"	1/2	20	510	Test effect of grinding the face of the T-pad.	Bond failure at viton to heater interface. Poor contacts due to thin viton.
R-163	35-0	35-0	60	1/8"	120	20	510	Test effect of grinding the face of the T-pad and higher bonding pressure.	Bond failure at viton to heater interface. Higher bonding pressure improves the contact.
R-171	35-0	35-0	60	1/8-1/4	0	20	500	Test effect of bonding two layers of viton together.	Bond failure at viton to load plate. Poor contact due to stiffness of combined viton.
R-183	35-0	35-0	60	1/8-1/8-1/8	90	20	500	Test effect of bonding three layers of viton together.	Bond failure at H. Contact not adequate, but improved.

* Abreviation for Heater-Tension Pad
** L refers to the Loadplate-Pad interface
\+ H refers to the Heater-Pad interface
\++ S refers to the Heater-Structure interface

TABLE 2 (Continued)

HTF	Adhesive L	Adhesive H	Adhesive S	Pad Thickness	Time Hours	Load PSI	Temp. of	Object	Results and Conclusions
R-116	35	35-DA	60	1/4	100	20	510	Test bonding contact with thicker viton.	Thicker pad improves contact somewhat.
R-120	35-0	35-0	60	1/4	120	20	510	"	"
R-155	35-0	35-0	60	1/4	0	20	510	"	Bond failure at H due to gas bubble caused by insufficient grooving.
R-191	60	ESP-4	ESP-4	1/4	110	15-20	510	Test new adhesive ESP-4 and light bonding pressure.	Bond failed at H when brought to 20 psi at 510°F. Higher bonding pressure needed.
R-199	ESP-4	ESP-4	ESP-4	1/4	100	12-15	510	"	Bond failed at H. Lack of contact due to light pressure.
R-200	60	ESP-4	ESP-4	1/4	59	15	510	Test new adhesive ESP-4 and the need for grooving at low pressure.	Bond failed at H. Lack of contact due to gas bubbles caused by lack of grooving of pad.
R-216	60	35-0 G.C.*	ESP-4	1/4	0	15	510	Test combination of 35-0 adhesive and glass cloth at H.	Bond failed at H when load was applied at temperature. This combination lacks strength.
R-275	60	35-0 G.C.	ESP-4	1/4	0	0	460	"	"

* Indicates that adhesive was calendered on glass cloth.

TALBE 2 (Continued)

HTP	Adhesive L	Adhesive H	Adhesive S	Pad Thickness	Time Hours	Load PSI	Temp. of	Object	Results and Conclusions
R-264	60	35-DA	ESP-4	1/4"	6 ½	20	460	Test combination of 35-DA adhesive and glass cloth at H.	Bond failed at H. This combination appears stronger than 35-0, but still lacks strength.
R-255	ESP-4	ESP-4	ESP-4	1/4"	10	20	450	Test method of bonding at L and H simultaneously.	Bond failed at H due to incomplete cure. Post cure schedule necessary.
R-263	ESP-4	ESP-4	ESP-4	1/4"	10	20	470	"	"
R-274	ESP-4	ESP-4	ESP-4	1/4"	3 ½	15	460	"	Bond failed at H due to lack of adequate post cure schedule.

TABLE 3

ADHESIVES INVESTIGATED

DESIGNATION NO.	DESCRIPTION	SOURCE
6-127	Silastic 6-127	Dow Corning Corp. 2722 Taylor St. Dallas 26, Texas
792	Primer 792	"
201 A	Experimental adhesive 9EW-201A	"
196 A	9EW-196A	"
35	Forest Products Laboratory #878, phenolic-epoxy	Physics Department University of Colorado
35-0	878 with fine pigment of aluminum oxide filler	"
35-0A	878 with course pigment of aluminum oxide filler	"
60	70.1% #35 adhesive 29.9% Alcoa Pigment #123	Physics Department University of Colorado
R.T.V. 60	Silastic RTV 60 Room temperature vulcanizing	Dow Corning Corp. 2722 Taylor St. Dallas 26, Texas
5302	Epoxylite 5302	The Epoxylite Corp. El Monte, California
ESP-4	Metalbond 311 - Epoxy - Silicone, Phenolic on asbestos cloth carrier.	Narmco Resins and Coatings Co., 600 Victoria St., Costa Mesa, Calif.
X 314	Liquid version of metalbond 311	"

TABLE 4

INFORMATION ON ELASTOMERS

DESIGNATION NO.	DESCRIPTION	SOURCE
80	Silastic 80	Dow Corning Corp.
Viton-A	Fluorinated Elastomer brown color	E. I. Dupont De Nemours and Co., Elastomer Chemicals, Dept. 2930 E. 44th St., Los Angeles 58, California
Viton-B	Fluorinated Elastomer black color	"

1/8 inch thick Viton at reasonable bonding pressure. Due mainly to this effect, only 4 pads out of 30 made with 1/8 inch thick Viton and the pigmented 878 adhesive withstood the 500°F, 20 psi. test for 100 or more hours. However, since 3 out of 6 similar pads using 1/4 inch Viton successfully withstood the same test, it appears that this type of pad should be reliable for operation at 500° and 20 psi. if 1/2 inch thick Viton were used. Unfortunately, on account of manufacturing difficulties 1/2 inch Viton was not available in time for further testing.

The ESP-4 adhesive is rated to withstand a temperature of 650°F without appreciable thermal degradation. This adhesive calendered on an asbestos cloth carrier proved to be very successful and reliable for bonding the heater to stainless steel structure. However, its use at the heater-Viton interface was rather unsuccessful. Instead of raising the operational temperature to an expected 550°F or 600°F at 20 psi., only three Viton pads of the many constructed using ESP-4 withstood 500°F at <u>15 psi</u>. for 100 hours.

3.4 EXPERIMENTAL TECHNIQUES

3.4.1 <u>Bonding Set-Ups</u>

A Vacuum-Bag Laminator* was used in bonding the silastic 80 and Viton-heater-tension pads which required a curing temperature of 300°F. For bonding similar pads employing ESP-4 which requires a curing temperature of 500°F, a Carver Hydraulic Laminator was used for most of the bonding. However, a few of the bonds were accomplished in a 500°F oven using dead weights to produce the bonding pressure.

* Final Report "Research on Heater-Tension Pads for Simulating Aerodynamic Heating and Loading," July 31, 1958, Contract AF 33(616)-3917.

3.4.2 Endurance Test Set-Up

The H-T pads were subjected to test loads by means of a loading rig which was actuated by a hydraulic jack. The load was adjusted by means of a pressure reducer in the air line and the load was indicated by means of an air pressure gauge. The actual force exerted by the jack at a given pressure was determined by means of a platform scale. The loading rig consisted of eight yoke type cradles in series to test one to eight H-T pads at one time. The cradles were arranged with checks to take over the load in case of a pad failure. The checks were cushioned in order not to over-load other pads being tested at the time one failed. After some refinements had been made, the loading rig proved to be fairly convenient. The design saved considerable test area space and did the work of 8 jacks, regulators, pressure gauges and separate loading rigs. The power input to each heater was regulated by means of a variac or powerstat monitored by means of a wattmeter which could be jacked into any heater circuit at will. The temperature of each H-T pad was indicated by iron-constantan thermo-couples bonded into the heater-structure plate interface with the couple junction located at the center of each heater. The temperatures were monitored by a pyrometer which could be connected to any thermo-couple at will. The arrangement proved to be very convenient and with constant line voltage the temperatures remained within 5 to 10°F of the desired value. The use of automatic control equipment was therefore not necessary.

4. TEMPERATURE DISTRIBUTION ON A HONEYCOMB PANEL*

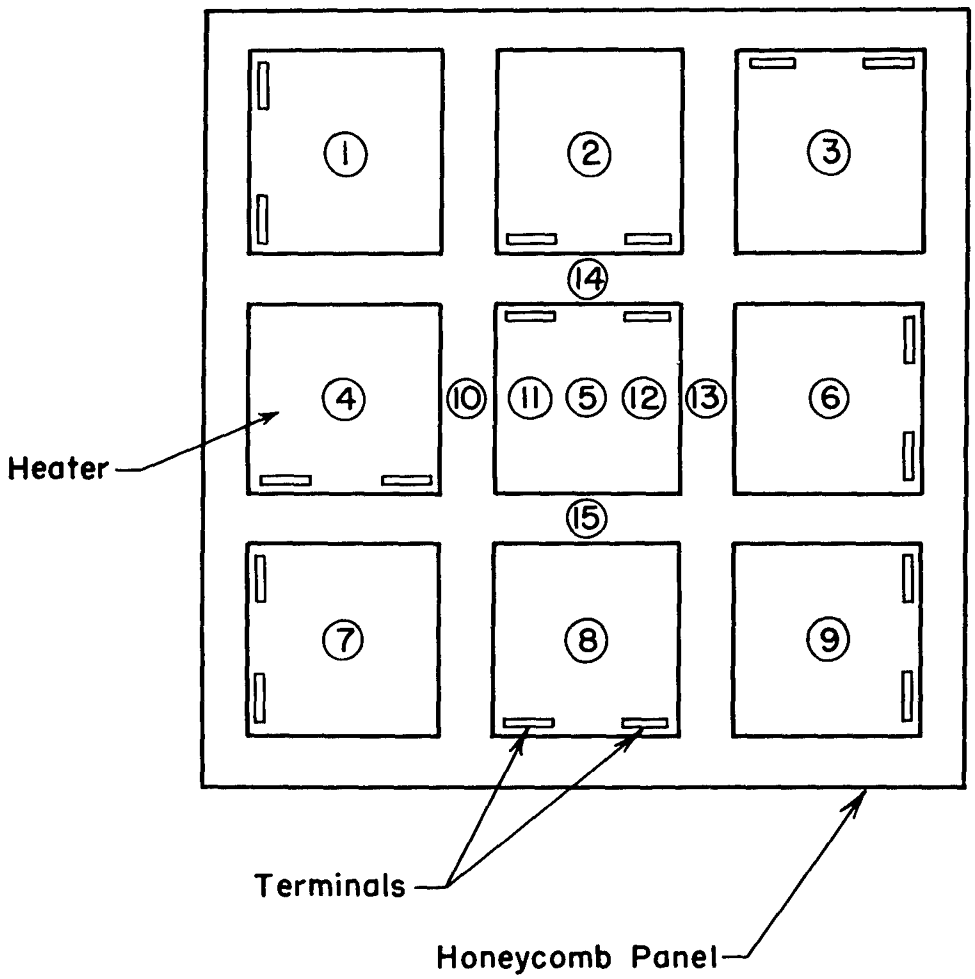
Nine heaters (without tension pads) were bonded to a 1 x 21 x 21 inch stainless steel honey-comb test section as shown in figure 1. The object of the first test was to check the thermal symmetry of the heaters and test panel. This was done by operating all but the central heater with the heater temperatures at thermo-couple numbers 1, 2, 3, 6, 9, 8, 7 and 4 adjusted to 505°F and noting the temperatures at thermo-couple locations 4, 10, 11, 5, 12, 13 and 6. The temperatures at these respective points were determined to be 505, 370, 250, 235, 260, 355 and 505°F. The thermal symmetry appeared to be reasonably good.

The object of the next test was to observe the temperature distribution over the central region with all heaters operating and the heater inputs adjusted to produce a temperature of 505°F at the center of each heater. The temperatures at points 4, 10, 11, 5, 12, 13, 6, 14 and 15 were determined to be 505, 485, 505, 510, 485, 505, 440, and 500 respectively. All readings were within 20° of 505°F except the 440° reading at point 14. This low reading may be accounted for by noting that point 14 is located between the cooler terminal ends of heaters 2 and 5. This may be avoided by orienting the heaters so that the terminal ends of two neighboring heaters are never adjacent to each other.

* Tests were performed jointly with a visiting member of the Structures Division of the North American Aviation Co., of Los Angeles, California.

FIGURE I

ARRANGEMENT OF HEATERS ON HONEYCOMB PANEL FOR TEMPERATURE DISTRIBUTION TESTS



Thermocouple junctions are located at the center of the circles.

5. CONCLUSION

Experience gained with over one hundred micro-film heaters incorporated into Heater-Tension Pads indicates a high degree of reliability. With few exceptions, premature failure of a heater was accounted for by lack of thermal contact due to faulty bonding or by short-circuiting caused by the use of an electrically conducting adhesive in contact with the exposed heater film. The first defect will be eliminated with the use of softer pads, (sponged silastic 80 is now available) and the second by precoating the heater film with any one of several available electrically insulating materials.

Experimental results show that the "Silastic 80" Heater-Tension Pad can now be built with sufficient reliability for operation at 500°F and 20 psi. to warrant completing the reliability tests originally scheduled.

Although the results in bonding the heater to "Viton" pads with ESP 4 adhesive were disappointing, the surprising bond strength shown by small areas of contact suggest that the use of thicker Viton pads may overcome the difficulty. The solution of this problem would also be aided by using sponged Viton which has just recently become available.

The desired uniformity of temperature distribution of honey-comb structures heated by means of Heater-Tension pads will be attained by properly orienting the heaters and by closer control of the heater film distribution.

APPENDIX A

SILASTIC 80 TENSION PAD BONDING PROCEDURES

A-1 BONDING THE LOAD PLATE TO THE SILASTIC 80 PAD WITH 6-127 ADHESIVE

a. Sandblast and clean the load plate with acetone. Prime the load plate with #796 primer and allow to dry for 30 min. Score the pad at 1 inch intervals 1/8" deep by 1/32" wide with a mill or some similar instrument.

b. Cut notches for terminals.

c. Clean the pad with toluene.

d. Bake the pad to remove any toluene at 300°F for 30 minutes.

e. Place the 6-127 adhesive on a clean load plate.

f. When the pad has cooled to room temperature, place it firmly in contact with adhesive on the load plate.

g. Cure the bond at 300°F for 30 minutes with at least 15 psi.

A-2 BONDING THE TENSION PAD TO THE HEATER TO FORM THE HEATER TENSION PAD (H-T-P).

a. Score the pad as in step a. above.

b. Clean the pad with toluene.

c. Bake the pad as in step d. above.

d. Coat the terminals with 6-127 dissolved in xylene and cure 30 minutes at 300°F.

e. Clean the heater face very lightly with acetone on a gauze pad and prime it with #796 primer.

f. Place the 6-127 adhesive on the pad firmly.

g. Place the heater in contact with the adhesive.

h. Cure the bond at 300°F with at least 15 psi. for 30 minutes.
Care must be taken not to puncture the heater from the foil side.

A-3 BONDING THE H-T-P TO STRUCTURE

a. Sandblast and clean the structure with acetone.

b. Spray the structure with #60 adhesive and allow it to dry until the adhesive loses its tackiness.

c. Roughen the back of the heater with an 80 grit size aluminum oxide sandpaper.

d. Clean the heater back with acetone.

e. Spray adhesive #60 on the heater back.

f. Precure the adhesive on the heater back at 270°F until the adhesive loses its tackiness.

g. Place the thermocouple carefully in the groove provided for it on the back of the heater.

h. Place the heater back in contact with the adhesive on the structure.

i. Cure the bond at 350°F with at least 15 psi. for 30 minutes.

j. Post cure the bonds at 450°F for 4 hours.

APPENDIX B

VITON TENSION PAD BONDING PROCEDURES

B-1 BOND OF VITON TO LOAD PLATE USING #60 ADHESIVE OR ESP-4 (METAL BOND X-311)

a. Sand blast the load plate to get a velvety sheen. The load plate must be flat and smooth, free from any large dents, bumps, or scratches.

b. Clean the sandblasted load plate with acetone on a gauze pad, or use vapor degreaser technique.

c. Buff the Viton pad on a soft wire wheel to destroy the slick sheen on the pad.

d. Groove the Viton pad with a mill or similar instrument. The grooves are spaced at one-inch intervals 1/8" deep by 1/3" wide. Cut slots for the terminals (see design of pad).

e. Clean the grooved and buffed surface of the Viton with ethyl acetate soaked gauze pads, then bake at 450°F for about 10 minutes.

f. Coat the surface of both the load plate and the Viton pad with #60 adhesive and precure at 270°F until the adhesive loses its tackiness. If ESP-4 is used, follow the same procedure.

g. Remove the precured pad and the load plate from the oven and place the two surfaces together and apply a pressure of 15 to 50 psi. and cure. If adhesive #60 is used, cure at 300°F for 30 minutes. If ESP-4 is used step cure as follows: 300°F for 1/2 hour, 400°F for 1 hour, and 480°F for 4 hours.

B-2 BONDING THE HEATER TO THE T-PAD

a. Buss-bar the terminals of the heater by French folding the aluminum foil at the terminal end.

b. Brush the heater surface with a soft brush to remove the dust, then power test the heater at 120v to a temperature of 500°F. The heater must remain at 500°F for one minute without failure, cracking, or showing any hot spots.

c. Clean both sides of the heater lightly with acetone and gauze pad.

d. Coat the terminals with SR-98 adhesive in solution, leaving 1/2" clear at the end. Care must be taken not to get SR-98 on the heater. Cure the terminals at 350°F for 1/2 hour.

e. Coat the heater with a thin smooth coat of adhesive #35 or unpigmented X-311 by spraying or painting to protect it from shorting.

f. Cure the adhesive #35 at 300°F or the X-311 at 400°F for 1 hour.

g. Smooth the Viton T-pad with a high speed grind wheel so that the surface of the Viton is flat.

h. Buff, groove, and clean the T-pad as in the bonding of the Viton to the load plate.

i. The sealed and tested heater is bonded to the T-pad with adhesive ESP-4 or X-311 pigmented and calendered.

j. Cure the bond 300°F for 1/2 hour, 400°F for 1 hour, and 475°F for 4 hours under 5 to 10 psi. A 24 hour post cure is recommended.

B-3 BONDING THE H-T PAD TO STRUCTURE

The bond to structure with Viton H-T pad is accomplished in the same manner as the bond to structure with the silastic 80 H-T pad. However, ESP-4 or X-311 adhesive may be used instead of adhesive #60 if the recommended step cure procedure is followed.

Aeronautical Systems Division, Dir/Engineering Test, Structural Division, Wright-Patterson AFB, Ohio.
Rpt Nr ASD-TDR-63-174, Pt I. RESEARCH ON HEATER-TENSION PADS AND HIGH TEMPERATURE HEATERS: Evaluation of Heater-Tension Pads at 500°F. Interim report, Apr 62, 22p. incl illus., tables.

Unclassified Report

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plications to large scale testing. The procedures for constructing "500°F 20 psi." heater-tension pads employing a silicone rubber and phenolic-epoxy adhesives have been established. Endurance tests indicate a high degree of reliability. Success in building heater-tension pads utilizing a fluorinated elastomer "Viton" for operation at 600°F and 20 psi. has been delayed by difficulties in bonding to the Viton. However, the availability of thicker and sponged Viton suggests that this problem can now be solved. Tests made on the temperature distribution of honey-comb structures indicate that the desired degree of uniformity can be attained.

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